Name(s) of Risk Team Members: J. Scott, R. Savage, T. Nehring, R. Karol, F. Dusek, M. Sivertz, L. Vogt, A. McNerney, J. Sandberg	Point Value → Parameter ↓	1	2	3	4	5
Area/Facility Description Title: Collider-Accelerator Department Area/Facility # (if applicable): Facility-Wide Electrical FRA 1-07	Occupancy or Use	≤once/year	≤once/month	≤once/week	≤once/shift	>once/shift
Area/Facility Description: Facility-Wide	Severity	First Aid Only	Medical Treatment	Lost Time	Partial Disability	Death or Permanent Disability
Approved by: *E. Lessard* Date: June 5, 2008 Rev.#: 1	Likelihood	Extremely Unlikely	Unlikely	Possible	Probable	Multiple

Reason for Revision (if applicable):

Recent reviews of installed electrical distribution equipment at C-AD have revealed circuits whereby the circuit breakers and fuses are not rated to handle a full fault current.

Comments:

			Before Additional Controls					After Additional Controls				
Physical Item or Activity	Hazard(s)	Control(s)	**Occupancy A**	**Severity B**	**Likelihood C**	**Risk* AxBxC**	Control(s) Added to Reduce Risk	**Occupancy A**	**Severity B**	**Likelihood C**	**Risk* AxBxC**	% Risk Reduction
Failed interrupt capability following a full fault current short (aka bolted short circuit). The likelihood of this event is assumed to be 1/10 years.	Blast and fire at location of circuit breaker or fuse; cabinets not guaranteed to contain damage and circuit breakers not guaranteed to open circuit	Work planning; access to these circuit breaker and fuse locations is limited to an 'as needed basis', some locations are posted with warnings, some locations are tagged to prevent local operation; Do Not Operate Tags are being used.	3	5	3	45	Controls to be added: The findings of a consultant are being evaluated by the Chief Electrical Engineer. A plan will be developed to ensure these hazards are either eliminated or mitigated.					
Some feeder cables are not temperature rated the same as the rating on connected equipment – connections may loosen due to different expansion and contraction	Overheating and fire	Smoke detection, fire alarms, local on-site fire fighters, appropriate egress and exits in the event of fire, training in emergency response	3	3	3	9	Controls to be added: The findings of a consultant are being evaluated by the Chief Electrical Engineer. A plan will be developed to ensure these hazards are either eliminated or mitigated.					

Electrical Equipment & Power Supplies BNL Class A & B <250 VAC; <1000Vdc	Shock or electrocution	All equipment is listed or reviewed by CEE or designee; Tier 1; PPE; inspections; disconnected cable policy; installations comply with applicable codes; procedures; training; distribution drawings; LOTO; Kirk keys; working hot permits; ASSRC/ESRC reviews; qualified electricians and technicians; cabinet interlocks; postings; locked areas; guarding; work planning; GFCI; grounding standards; emergency procedures, temporary wiring installations are now tracked and when due they are removed or converted to permanent wiring. An ECN is required prior to issuing a work order for all work on the power distribution system. A drawing or a sketch and a printed label or panel directory is now issued with the work order. Electricians have been assigned to label existing disconnects. Notes 1-7 below have been fully completed or dispositioned and tracked to completion.	5	3	2	30						
Electrical Equipment & Power Supplies BNL Class C <600 VAC; <6000 VDC	Shock or electrocution	All equipment is listed or reviewed by CEE or designee; Tier 1; PPE; inspections; disconnected cable policy; installations comply with applicable codes; procedures; training; distribution drawings; LOTO; Kirk keys; working hot permits; ASSRC/ESRC reviews; qualified electricians and technicians; cabinet interlocks; postings; locked areas; guarding; work planning; GFCI; grounding standards; emergency procedures; two-person rule for hot work. Notes 1-7 below either fully implemented or dispositioned and being tracked to completion	4	4	2	32						
Electrical Equipment & Power Supplies BNL Class C <600 VAC; <6000 VDC	Arc blast; burn	Procedures, training, PPE, implementation of NFPA 70E+. Notes 1-7 below either fully implemented or dispositioned and tracked to completion	4	2	2	16						
Electrical Equipment & Power Supplies BNL Class D >600 VAC; >6000 VDC	Shock or electrocution	All equipment is listed or reviewed by CEE or designee; Tier 1; PPE; inspections; disconnected cable policy; installations comply with applicable codes; procedures; training; distribution drawings; LOTO; Kirk keys; working hot permits; ASSRC/ESRC reviews; qualified electricians and technicians; cabinet interlocks; postings; locked areas; guarding; work planning; GFCI; grounding standards; emergency procedures; safety watch for hot work. Notes 1-7 below either fully implemented or dispositioned and tracked to completion	2	4	2	16						
Electrical Equipment & Power Supplies BNL Class D >600 VAC; >6000 VDC	Arc blast; burn	Procedures, training, PPE, implementation of NFPA 70E+. Notes 1-7 below either fully implemented or dispositioned, and tracked to completion	2	2	2	8						
Extension Chords; Temporary Wiring And Power Strips	Shock or electrocution	All equipment is listed or reviewed by CEE or designee; Tier 1; PPE; inspections; disconnected cable policy; installations comply with applicable codes; procedures; training; distribution drawings; qualified electricians and technicians; GFCI; grounding standards. Notes 1-7 below either fully implemented or dispositioned, and tracked to completion.	5	4	2	40						
Transformer And Switch Yards	Shock or electrocution	All equipment is listed or reviewed by CEE or designee; Tier 1; PPE; inspections; installations comply with applicable codes; procedures; training; LOTO; qualified electricians; postings; locked areas; work planning; grounding standards; emergency procedures; grounding before work start Notes 1-7 below either fully implemented or tracked to completion.	2	4	2	16						
Transformer And Switch Yards	Arc blast;burn	PPE; procedures; training; qualified electricians, Implementation of NFPA 70E+. Notes 1-7 below either fully implemented or tracked to completion.	2	2	2	8						
Underground/Overhead Cables/Wiring	Shock or electrocution	All equipment is listed or reviewed by CEE or designee; installations comply with applicable codes; PPE, procedures; training; distribution drawings; LOTO; Kirk keys; qualified electricians; postings; work planning; digging permit. Notes 1-7 below either fully implemented or tracked to completion.	2	4	2	16						
Batteries/UPS	Shock or electrocution	All equipment is listed or reviewed by CEE or designee; Tier 1; PPE; inspections; disconnected cable policy; installations comply with applicable codes; procedures; training; distribution drawings; LOTO; Kirk keys; working hot permits; ASSRC/ESRC reviews; qualified electricians and technicians; cabinet interlocks; postings; locked areas; guarding; work planning; grounding standards; emergency procedures. Notes 1-7 below either fully implemented or tracked to completion.	3	4	2	24						

Batteries/UPS	Molten spray	PPE; procedures; training. Notes 1-7 below either fully implemented or tracked to completion.	3	3	1	9							
Batteries/UPS	Being struck by an object, such as due to hydrogen gas explosion	PPE; procedures; training. Notes 1-7 below either fully implemented or tracked to completion.	3	3	2	18							
Standby Generators	Shock or electrocution	All equipment is listed or reviewed by CEE or designee; Tier 1; PPE; inspections; disconnected cable policy; installations comply with applicable codes; procedures; training; distribution drawings; LOTO; Kirk keys; working hot permits; ASSRC/ESRC reviews; qualified electricians and technicians; cabinet interlocks; postings; locked areas; guarding; work planning; grounding standards; emergency procedures. Notes 1-7 below either fully implemented or tracked to completion.	2	4	2	16							
Standby Generators	Noise	Hearing protection.	4	4	2	32							
Standby Generators	Entanglement	Guards for rotating parts, Barriers, PPE.	4	5	2	40							
Siemens And Westinghouse MG Sets	Shock or electrocution	All equipment is listed or reviewed by CEE or designee; Tier 1; PPE; inspections; disconnected cable policy; installations comply with applicable codes; procedures; training; distribution drawings; LOTO; Kirk keys; working hot permits; ASSRC/ESRC reviews; qualified electricians and technicians; cabinet interlocks; postings; locked areas; guarding; work planning; grounding standards; emergency procedures. Notes 1-7 below either fully implemented or tracked to completion.	5	4	2	40							
Siemens And Westinghouse MG Sets	Noise	Hearing protection, postings. Notes 1-7 below either fully implemented or tracked to completion.	4	4	2	32							
Siemens And Westinghouse MG Sets	Becoming caught in or compressed by equipment	Crash button for shut down; guards for rotating parts, Barriers; PPE; Notes 1-7 below either fully implemented or tracked to completion.	4	5	2	40							
General Wiring; Cable Trays; Buss Work	Shock or electrocution	All equipment is listed or reviewed by CEE or designee; Tier 1; PPE; inspections; disconnected cable policy; installations comply with applicable codes; procedures; training; distribution drawings; LOTO; Kirk keys; working hot permits; ASSRC/ESRC reviews; qualified electricians and technicians; cabinet interlocks; postings; locked areas; guarding; work planning; GFCI; grounding standards; emergency procedures. Notes 1-7 below either fully implemented or tracked to completion.	4	4	2	32							
Buss or electrical equipment cooling water	Being struck by an object from water jet or pressure	Tier 1 inspections; installations comply with applicable codes; PPE; procedures; training; distribution drawings; LOTO; work planning.	4	2	3	24							
Motor Control Centers; Panels And Wall Sockets	Shock or electrocution	All equipment is listed or reviewed by CEE or designee; Tier 1; PPE; inspections; disconnected cable policy; installations comply with applicable codes; procedures; training; distribution drawings; LOTO; Kirk keys; working hot permits; ASSRC/ESRC reviews; qualified electricians and technicians; cabinet interlocks; postings; locked areas; guarding; work planning; grounding standards. Notes 1-7 below either fully implemented or tracked to completion.	4	4	2	32							
Motor Control Centers; Panels And Wall Sockets	Arc blast; burn	PPE; training; procedures, Implementation of NFPA 70E+. Notes 1-7 below either fully implemented or tracked to completion	4	2	2	16							
Electrical Disconnects And Switches	Arc blast; burn	Procedures, training, PPE, Implementation of NFPA 70E+. Notes 1-7 below either fully implemented or tracked to completion.	4	2	2	16							
Electrical Disconnects And Switches	Shock or electrocution	All equipment is listed or reviewed by CEE or designee; Tier 1; PPE; inspections; disconnected cable policy; installations comply with applicable codes; procedures; training; distribution drawings; LOTO; Kirk keys; working hot permits; qualified electricians and technicians; cabinet interlocks; postings; locked areas; guarding; work planning; GFCI; grounding standards; emergency procedures; two-person rule for hot work Notes 1-7 below either fully implemented or tracked to completion..	4	4	2	32							

Circuit Breakers	Arc blast; flash	All equipment is listed or reviewed by CEE or designee; PPE; procedures; training, Implementation of NFPA 70E+. Notes 1-7 below either fully implemented or tracked to completion.	4	2	2	16							
Appliances And Computers	Shock or electrocution	All equipment is listed or reviewed by CEE or designee; Tier 1; PPE; inspections; disconnected cable policy; installations comply with applicable codes; procedures; training; distribution drawings; LOTO; Kirk keys; working hot permits; qualified electricians and technicians; cabinet interlocks; postings; locked areas; guarding; work planning; GFCI; grounding standards; emergency procedures; two-person rule for hot work. Notes 1-7 below either fully implemented or tracked to completion.	5	3	2	30							
Vacuum Pumps	Shock or electrocution	All equipment is listed or reviewed by CEE or designee; Tier 1; PPE; inspections; disconnected cable policy; installations comply with applicable codes; procedures; training; LOTO; Kirk keys; working hot permits; ASSRC/ESRC reviews; qualified electricians and technicians; postings; work planning; grounding standards. Notes 1-7 below either fully implemented or tracked to completion.	3	4	2	24							
Magnets	Shock or electrocution	All equipment is listed or reviewed by CEE or designee; Tier 1; PPE; inspections; disconnected cable policy; installations comply with applicable codes; procedures; training; distribution drawings; LOTO; Kirk keys; working hot permits; ASSRC/ESRC reviews; qualified electricians and technicians; postings; locked areas; guarding; work planning; grounding standards. Notes 1-7 below either fully implemented or tracked to completion.	4	4	2	32							
Magnets	Magnetic fields	PPE, Posting; fencing; warnings; magnet design reviews; field measurements; medicals; work planning; ASSRC reviews; work planning. Notes 1-7 below either fully implemented or tracked to completion.	2	3	3	18							
Capacitors/inductors	Shock or electrocution	All equipment is listed or reviewed by CEE or designee; Tier 1; PPE; inspections; disconnected cable policy; installations comply with applicable codes; procedures; training; distribution drawings; LOTO; Kirk keys; working hot permits; ASSRC/ESRC reviews; qualified electricians and technicians; postings; locked areas; guarding; work planning; grounding standards. Notes 1-7 below either fully implemented or tracked to completion.	3	4	2	24							
Beam Components and Instrumentation	Shock or electrocution	All equipment is listed or reviewed by CEE or designee; Tier 1, PPE, inspections; disconnected cable policy; installations comply with applicable codes; procedures; training; distribution drawings; LOTO; Kirk keys; working hot permits; ASSRC/ESRC reviews; qualified electricians and technicians; postings; locked areas; guarding; work planning; grounding standards. Notes 1-7 below either fully implemented or tracked to completion.	3	4	2	24							
Beam Components and Instrumentation	Being struck by an object, due to moving parts remotely operated	Guards for moving parts, PPE.	2	3	3	18							
Electrical Powered Hand Tools	Shock or electrocution	All equipment is listed or reviewed by CEE or designee; Tier 1; PPE; inspections; procedures; training; labeling; work planning; GFCI; grounding standards; double insulation. Notes 1-4 below either fully implemented or tracked to completion.	5	3	2	30							
RF Cavities	Shock or electrocution	All equipment is listed or reviewed by CEE or designee; Tier 1; PPE; inspections; disconnected cable policy; installations comply with applicable codes; procedures; training; LOTO; Kirk keys; working hot permits; ASSRC/ESRC reviews; locked areas; guarding; work planning; grounding standards; emergency procedures. Notes 1-4 below either fully implemented or tracked to completion.	3	4	2	24							
RF Cavities	Rf field	RF gaskets; interlocked areas.	3	2	2	12							
RF Cavities	Noise	Hearing protection.	3	2	2	12							
RF Cavities	Radiation exposure from X-rays	Access controls; shielding; training; RCD surveys; postings; locked areas; procedures for test areas; RWP; work planning.	5	4	2	40							

Confined Spaces - Metal	Increased chance of shock due of proximity to conducting surfaces	All equipment is listed or reviewed by CEE or designee; work planning; grounding standards; GFCI; LOTO, PPE.	2	4	2	16						

Further Description of Controls Added to Reduce Risk:

NOTE 1: OSHA Teams visited C-AD during the period October 20 through October 31, 2003 and recorded electrical non-compliances. All OSHA findings have been closed by full compliance or with an equivalent level of safety. The status of the OSHA items are maintained in BNL's Compliance suite, and closed on a schedule commensurate with funding.

NOTE 2: A compliance plan to have all non-listed electrical installations accepted by an Authority Having Jurisdiction (AHJ), as per 29CFR1910 Subpart S, has been implemented by BNL. UL, CSA, LLC or other NRTL accepted equipment will be acquired at BNL for all future installations. Prior installations are under review and will be accepted by trained, qualified AHJs. The inspection plan must be completed by 2009.

NOTE 3: Full compliance with NFPA 70E was adopted by the C-AD in December 2005. NFPA 70E prescribes protective clothing to protect against shock and arc blast; thus reducing the severity and likelihood of an injury. It also prescribes training, which is currently fulfilled by taking the Electrical Safety 1 and by attending the C-AD 3-hour classroom course on electrical safety rules and PPE. C-A-OPM 1.5.3, Procedure to Open or Close Circuit Breakers, Disconnect Switches, MCC Starters, Meter Switches and Connecting/Disconnecting Plugs" which covers arc flash/blast hazards is more stringent than NFPA 70E in that it prevents injury from arc flash by preventing any burns to skin.

NOTE 4: Contractor and vendor training in work planning and electrical safety has been improved. Plans to reach all contractors and vendors with regard to NFPA 70E requirements prior to performing work at BNL have been implemented. C-AD has obtained lists of all its vendors and suppliers and is ensuring that they take Electrical Safety 1 or have equivalent training if needed.

NOTE 5: In March 2007, many C-AD electrical engineers, technical supervisors and electricians took a 2-day NEC course given by Stallcup using the 2005 NEC Code and Stallcup's Electrical Design Book.

NOTE 6: New OPMs have been issued to cover electrical safety and to improve awareness and control of potential unsafe conditions during electrical operations, troubleshooting and work:

1. C-A-OPM 1.5.4, Modification of Nationally Recognized Test Laboratory Listed Equipment
2. C-A-OPM 2.36, Lock and Tag Program for Control of Hazardous Energy
3. C-A-OPM 2.39, Response to a Ground Fault Alarm at C-AD
4. C-A-OPM 15.3.3.3, Siemens Operator, Siemens Transformer Yard Inspection
5. C-A-OPM 15.3.6.1, Booster/AGS Ring Power Systems Group Nitrogen and Transformer Yard Inspection Procedure
6. C-A-OPM 16.2.2, C-AD Substations Inspection Procedure

NOTE 7: GE Spectra disconnect switches of the type that were involved in the STAR arc-flash event have been replaced with better fabricated disconnects or breakers. See for example the new STAR magnet breaker panel in B1006 and associated C-A-OPMs Series 11.4.3.

*Risk:	0 to 20	21 to 40	41-60	61 to 80	81 or greater
	Negligible	Acceptable	Moderate	Substantial	Intolerable